ATTACHMENT

Application Serial No. 09/836,630

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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :

SEIICHI IZUMI : EXAMINER: SOON D. HYUN

SERIAL NO: 09/836,630 :

FILED: APRIL 17, 2001 : GROUP ART UNIT: 2616

FOR: OFDM DIVERSITY TRANSMISSION :

DECLARATION OF PRIOR INVENTION UNDER 37 C.F.R. § 1.131

COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313

SIR:

1. I, Seiichi IZUMI, am the named inventor of the present application. I hereby swear that the present invention was conceived at least by March 21, 2000, as evidenced by the attached Report of Invention.

2. All claims now pending in the present application are supported by the Report of Invention submitted to my company's management prior to March 21, 2000 (Attachment 1).

3. Applicant exercised due diligence from conception to the filing date of April 18, 2000 of priority document EP 00 108 459.9. As such, Applicant is entitled to an earlier date of invention with respect to the reference of record.

5. The undersigned declares that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

Seiichi IZUMI

Date: January 15, 2007

REPORT OF INVENTION / ERFINDUNGSMELDUNG
CONFIDENTIAL / VERTRAULICH

FORM A-1 1/3
990811

Laboratory Manager → Sony Europe GmbH - Intellectual Property Office (IPO)

To be completed by Laboratory Manager

Class	Comments
[ ] A [X] B [ ] C	Comments It is an important idea However, it needs to be carefully assessed, as there may be patent in this area. Signature:

To be completed by IPO

Received on	PAE No.
	PAE00-0147TRDE

To be completed by the Inventor(s) in English and to be directed to Lab Manager.
Von dem/den Erfinder (n) auf Englisch auszufüllen und bei Laborleiter einzureichen

Hereby I/we report the following service invention described in the enclosure. Hiermit melde(n) ich/wir die in der Anlage beschriebene Diensterfindung.	
1) Title / Titel	OFDM radio air link
2) Abstract of the invention (Problem and Solution) / Kurze Beschreibung der Erfindung (Aufgabe und Lösungsgedanke)	In the radio air link, there is a problem of fading. To avoid or compensate fading, several techniques are considered such as RX and TX diversity, frequency hopping etc. This invention is about new ideas of TX diversity, which phase (and amplitude) adjustment is calculated in the same (transmitter) side and no orthogonal signaling is required. So that number of antenna can be increased as much as possible to get shaper beam. As results, this invention can remove fading and reduce interference by make both up and down link transmit power smaller.
The following person(s) are inventor/co-inventors of the invention. Am Zustandekommen der Erfindung sind als Erfinder/Miterfinder die folgenden Personen beteiligt.	
3) Last Name / Name First name / Vorname	IZUMI Seiichi
4) Home Address / Privatanschrift	Meißner Straße 36 D-70736 Fellbach
5) Nationality/Staatsangehörigkeit	Japanese
6) Personal No./ Pers.-Nr.	201091 (850003 in Japan)
7) Position / Dienststellung Department / Abteilung Company / Firma Phone / Telefon FAX / FAX E-mail / E-mail Supervisor / Vorgesetzter	Principle Engineer TRDE Sony International (Europe) GmbH. +49 711 5858 180 +49 711 5858 468 izumi@fb.sony.de Hamid Amir-Alikhani
8) Duties of the inventor(s) in the company / Aufgabenbereich des(der) Erfinder im Unternehmen	Resarch
9) Professional education / Die berufliche Aus-/Vorbildung	
10) Contribution/Erfinderanteil (%)	100%

REPORT OF INVENTION / ERFINDUNGSMELDUNG

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990811

In case of multiple inventors, Please separately describe for each inventor. /
Bei mehreren Erfindern, bitte für jeden Miterfinder gesondert schildern.

Creation of the invention / Zustandekommen der Erfindung

11) The setting of the problem / Stellung der Aufgabe

a. Does the problem lie in the general working field of the Inventor? If not, please explain. / Liegt die Aufgabe auf dem allgemeinen Arbeitsgebiet des Erfinder? Wenn nicht, bitte begründen. b. Was there a direct order for the works leading to the invention? If yes, who (e.g. supervisor, customer) did assign the problem and how? Which information about the way of solution was given? If not, what caused the works leading to the invention? How did the inventor obtain the knowledge of shortcomings and needs the invention remedies? / Erfolgte ein direkter Auftrag für die Arbeiten, die zu der Erfindung führten? Wenn ja, wer (z.B. Vorgesetzter, Kunde) hat die Aufgabe gestellt und wie? Welche Hiweise auf den Lösungsweg wurden gegeben? Wenn nicht, was gab den Anlaß zu den Arbeiten, die zu der Erfindung führten? Wie erlangte der Erfinder Kenntnis von Mängeln oder Bedürfnissen, denen durch die Erfindung abgeholfen wird?	Inventor's name / Name des Erfinders IZUMI, Seiichi Statement / Angabe a. Yes. b. Yes Dr. H.A.Alikhani has assigned me to this project. And my responsibility includes IPR activity.

12) The solution of the problem / Die Lösung der Aufgabe

a. To which extent did the company's experience and works play a role in solving the problem? / Inwiefern haben betriebliche Erfahrungen und Arbeiten eine Rolle Gespielt? b. Which technical assistance (power, raw material and/or equipment) was provided from the company? / Welche technischen Hilfsmittel (Energien, Rohstoffe und/oder Geräte) sind seitens des Unternehmens bereitgestellt worden? c. Was other employee, external man- power and/or work involved and who?/ Wurden Mitarbeiter einbezogen und/oder außerbetriebliche Kräfte u. Arbeiten nutzbar gemacht and wer?	Inventor's name / Name des Erfinders IZUMI, Seiichi Statement / Angabe a. 100% b. None. c. None.

REPORT OF INVENTION / ERFINDUNGSMELDUNG

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13) Project name and/or code, if any. / Projektname-/code, falls vorhanden
BRAIN

14) Development status / Entwicklungsstand:
Resarch.
15) Exploitation status of the invention / Auswertungsstand der Erfindung
Prepareing for simulation.
16) Plan to make the invention public (when, where, how) / Vorhaben zur Veröffentlichung der Erfindung (wann, wo, wie)
There is a possibility to propose this idea at BRAIN meeting in the future.
17) Other information / Sonstige Informationen:

Information about OFDM link is in
Broadband Radio Access Networks (BRAN); HIPERLAN Type 2 Functional Specification Part 1-Physical (PHY) layer.
Information about TX diversity of UMTS is in
3GPP Physical layer procedure. (FDD) TS 25.214(attached)

I/we confirm that the preceding and herewith enclosed statements, as far as they are known to us, are complete and correct.
I/We further confirm that further persons did not contribute to the invention. Further I/we declare explicitly as to the best of our knowledge that I/we are the first inventors of the invention.
I/we do not know of any prior use by other companies or persons.
We have been informed about the following: The invention may not be made available to the public either in writing, by use or oral communication, so long as it has not become free. Prior to this, no information containing the invention should be given to third parties including customers or cooperating companies and manuscripts or similar to be mailed to the publishers of periodicals.
(If this creates problems, please refer to Sony Europe – Intellectual Property Office.) /

Ich versichere (Wir versichern), daß die vorstehenden und in der Anlage beschriebenen Angaben, soweit bekannt, vollständig und richtig sind.
Ich versichere (Wir versichern), daß weitere Personen an der Erfindung nicht beteiligt sind.
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Eine frühere Benutzung durch andere Personen oder Firmen ist mir/uns nicht bekannt.
Wir sind über folgendes informiert: Die Erfindung darf der Öffentlichkeit weder schriftlich, noch durch Benutzung oder mündliche Mitteilung zugänglich gemacht werden, solange sie nicht frei geworden ist. Vorher dürfen keine die Erfindung betreffenden Informationen an Dritte einschließlich Kunden oder Entwicklungspartner weitergegeben oder Manuskripte und ähnliches an Redaktionen von Fachzeitschriften geschickt werden.
(Falls sich dadurch Probleme ergeben, besprechen Sie dies bitte mit Sony Europe – Intellectual Property Office.)

18) Date / Datum: 31,01,00
19) Signature / Unterschrift:

20) Enclosures / Anlagen:

Page 27 to 31 of 3GPP TS 25.214. (Chapter 8, Closed loop mode transmit diversity.)
Japanese patent WO98/56121
Japanese patent 11-148956

3. Others / Sonstiges:

DESCRIPTION OF THE INVENTION / BESCHREIBUNG DER ERFINDUNG

FORM A-2 1/2
990811

Please describe the invention. Please use the following structure./
Bitte beschreiben Sie die Erfindung. Benützen Sie dabei bitte folgende Gliederung.

1) External state of the art / Externer Stand der Technik:
What external state of the art concerning the invention is known to the inventor(s)?/
Welcher externe die Erfindung betreffende Stand der Technik ist dem Erfinder/den Erfindern bekannt?

In GSM, frequency hopping is used to average out fading.

In UMTS, TX diversity technique is used. Orthogonal symbol sequences are sent from two anntenas and receiver estimates both channel separately. Both channel informations are feed back to base station and it reflects the both channel information at individuall anntena. (Figure 1)(Prease refer attaced doc.)

In the Hyperlan 2, no TX diversity technique is used.

In beam forming of adapdive array anntena technique, I personally never seen combination with OFDM signal.
There is already idea of beam forming of TDD non OFDM communication. (Attached doc WO98/56121)
There is disclosed patent information uses FFT to detemine delay. (11-148956) But calculation is different.

2) Internal state of the art, if different from the above. / Interner Stand der Technik, falls abweichend von oben.
What previous work in the technical field in question has been done by the company before the invention was made? /
Welche vorherigen Arbeiten sind auf dem betreffenden technischen Gebiet durch den Betrieb vor dem Zustandekommen der Erfindung durchgeführt worden?

No difference.

3) Problem to be solved by the invention. The disadvantages, shortcomings or needs of the state of the art. /
Aufgabe der Erfindung. Die Nachteile, Mängel oder Bedürfnisse des Standes der Technik.

In wireless link, fading due to multi path delay is a big problem.
Frequency hopping requires a complex link assignment and circuit..
TX diversity technique of UMTS needs orthogonal coding of symbol sequences and closed loop. Number of antenna is limited by number of orthogonal signal.
Wireless link of hyperlan2 etc has no soludion for fading.

4) Solution proposed by the invention and embodiment(s) / Lösungsgedanke der Erfindung und Ausführungsbeispiel(e)

This inventions assumes following case

OFDM radio air link such as Hyperlan2 etc, which has following feature.
There are more than two antennas at base side,
Same frequency is used for both UP and DOWN link.

Following sequence of operation is done

1. Stabilize frequency of terminal to base.
2. At the base side, relative phase comparison of each antenna is performed using up-link signal. (Fig.6)(Fig.5 shows signal of each antenna down converted and also digitized.)
   For example, phase comparison is carried out like followings
   Compare phases between antennas by averaging each sub-carrier phase difference. Or
   Compare phases between antennas at reliable sub-carrier(s). (Figure 2) Or
   Correlate both time domain received data and calculate phase difference by dividing 2pi*delay by period.(Figure 3)
   Other ways can be considered.
   Before averaging, phase difference at each sub-carrier is adjusted to that of base sub-carrier. Because frequency of each sub-carrier is different. Base sub-carrier can be center sub-carrier or any sub-carrier, which can represent OFDM symbol.

3. Next time the base transmits, phase of signal at each antenna should be adjusted, so that the terminal receive receives same phase. (Fig.8)
   This is same as transmit timing at each antenna should be adjusted, so that the terminal can receive all signal at same timing.(Fig.7)

4. Next time the base receives, phases of signals should adjusted also. (If there is memory, phase adjustment in receiver side can be done in the same OFDM symbol.) And new phase difference is calculated for next transmission.

Also next operation can be available optionally.

η Value of adjustment can be averaged over several times to get confident value.
η If one (or some) of antenna(s) of the base can not receive up-link signal because of fading, those antenna(s) shall not used for transmitting down link.
η Amplitude adjustment at each antenna is also possible.
η This operation can be done in both side of OFDM link.

5) The main advantageous differences between the invention and the state of the art /
Die wesentlichen vorteilhaften Unterschiede zwischen der Erfindung und dem Stand der Technik

In this invention, terminal (mobile side) does not have to measure each path from different antennas. So that, no orthogonal signal for each channel is required.
Because number of antennas at base is not limited by number of orthogonal signal, as no orthogonal coding is needed, number of antennas at base can be as many as possible.
Then, antennas can be placed like adaptive array antennas and sharper beam is possible. (Figure 4)
Transmit power from both side can be reduced. Not only fading, but also interference can be reduced.

6) To what extent (%) did the state of the art contribute in bringing about the invention? /
Inwieweit (%) hat der Stand der Technik zum Zustandekommen der Erfindung beigetragen?

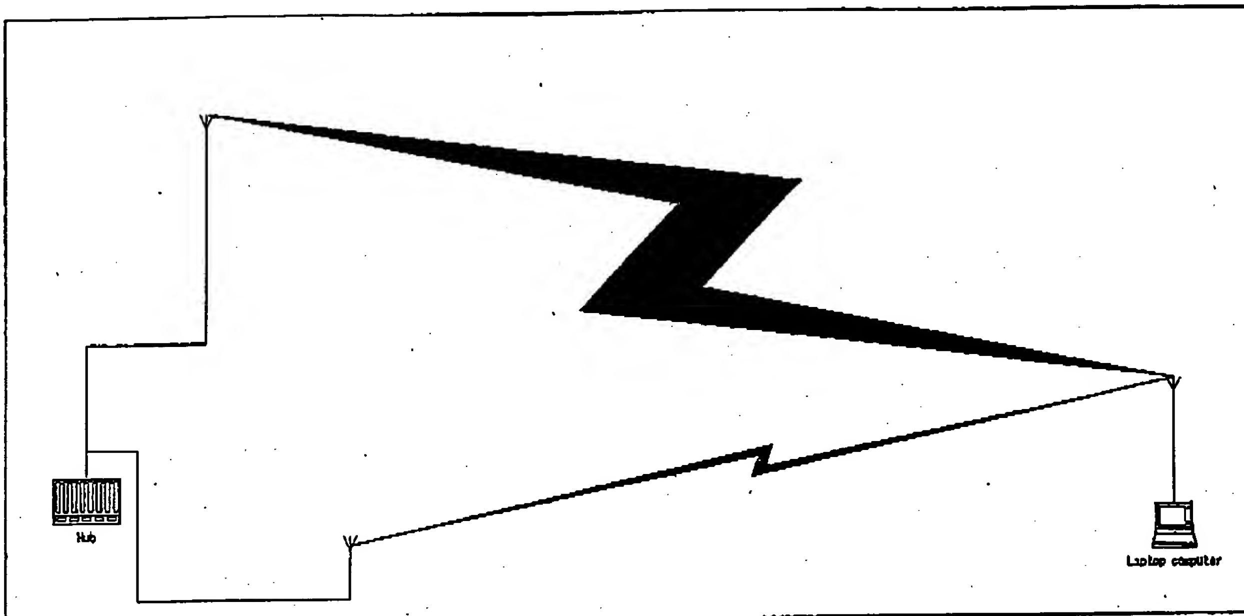
Hub
Laptop computer

Fig. 1

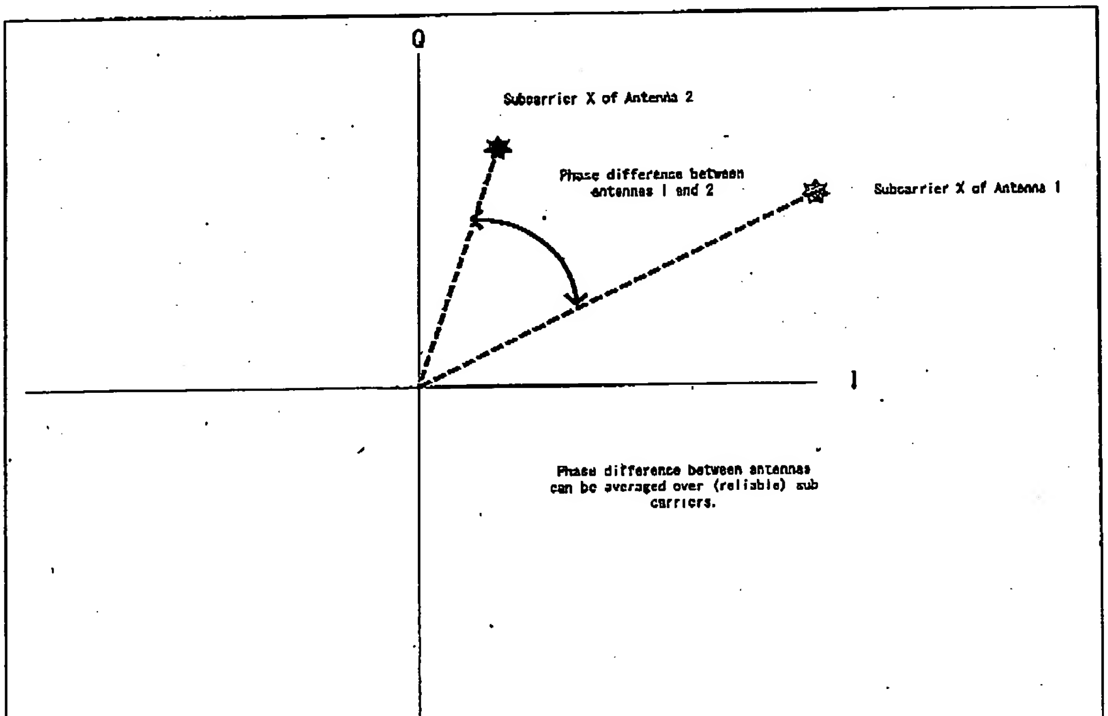
Q
Subcarrier X of Antenna 2
Phase difference between antennas 1 and 2
Subcarrier X of Antenna 1
I
Phase difference between antennas can be averaged over (reliable) sub carriers.

Fig. 2

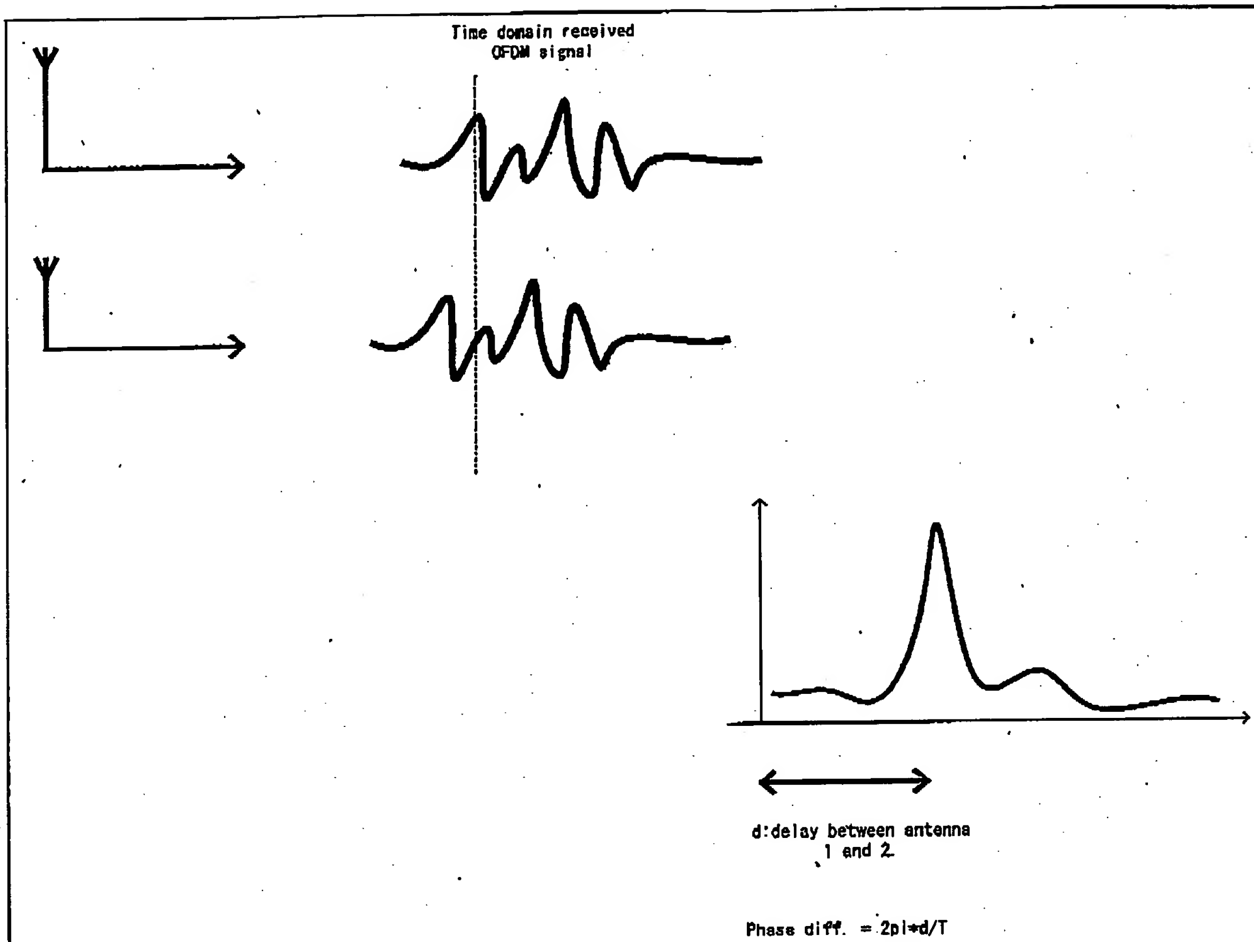
Time domain received
OFDM signal
d:delay between antenna
1 and 2
Phase diff. = 2pi*d/T

Fig. 3

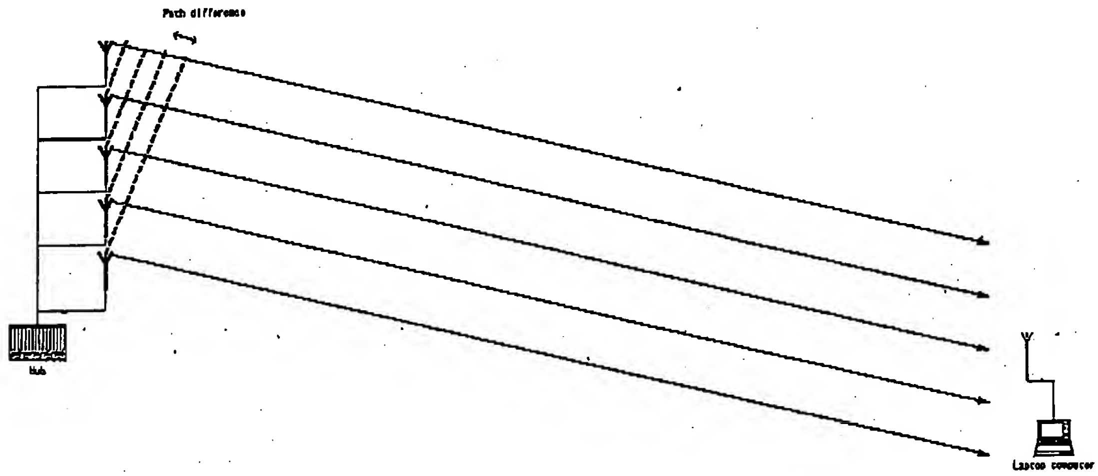
Path difference
Hub
Laptop computer

Fig. 4

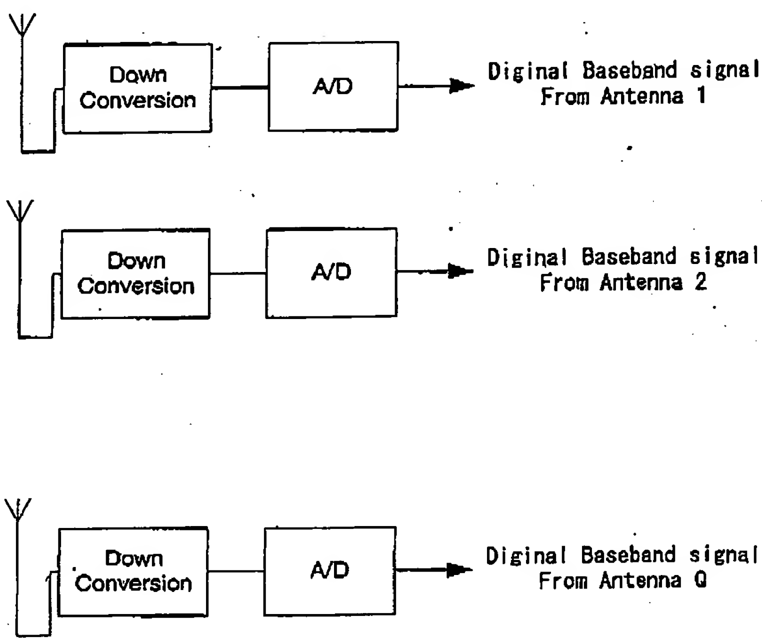
Down Conversion
A/D
Diginal Baseband signal From Antenna 1
Down Conversion
A/D
Diginal Baseband signal From Antenna 2
Down Conversion
A/D
Diginal Baseband signal From Antenna Q

Fig. 5

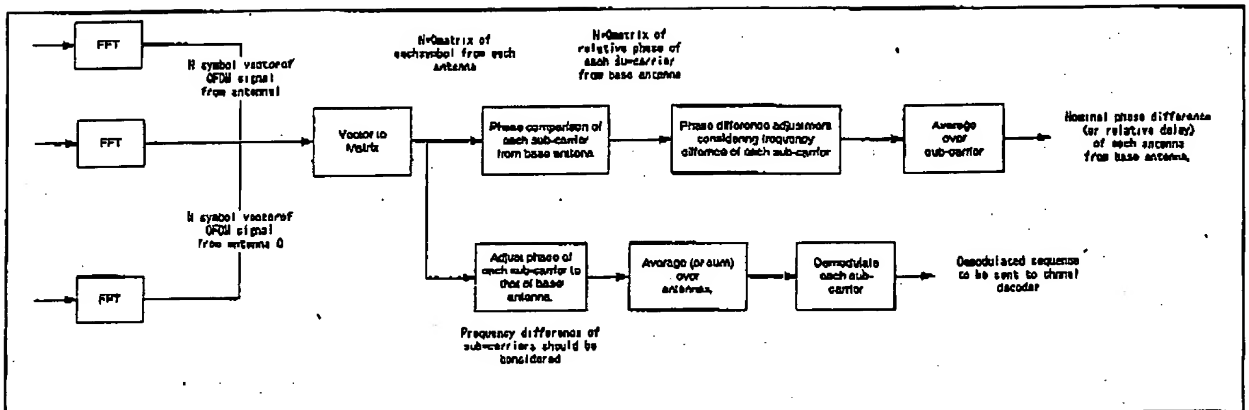

Fig. 6

$$
\begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_N \end{bmatrix},
\begin{bmatrix} s_{1,1} & s_{1,2} & \cdots & s_{1,Q} \\ s_{2,1} & s_{2,2} & \cdots & s_{2,Q} \\ \vdots & \vdots & \ddots & \vdots \\ s_{N,1} & s_{N,2} & \cdots & s_{N,Q} \end{bmatrix},
\begin{bmatrix} p_{1,1} & p_{1,2} & \cdots & 0 \\ p_{2,1} & p_{2,2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ p_{N,1} & p_{N,2} & \cdots & 0 \end{bmatrix},
\begin{bmatrix} p'_{1,1} & p'_{1,2} & \cdots & 0 \\ p'_{2,1} & p'_{2,2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ p'_{N,1} & p'_{N,2} & \cdots & 0 \end{bmatrix},
[p'_1 \quad p'_2 \quad \cdots \quad 0], [d_1 \quad d_2 \quad \cdots \quad 0]
$$

s_N : Constellation vector of each subcarrier

$s_{subcarrier, antenna}$: constellation of each subcarrier and antenna

$p_{subcarrier, antenna}$:relative phase differnce at each subcarrier from base antenna

$p'_{subcarrier, antenna}$: adjusted phase difference to nominal frequency (center frequency)

$p'_{antenna}$: averaged phase difference from base antenna at nominal frequency

$d_{antenna}$: delay of each antenna from base anttena

Vector and Matrix appears in the fig. 6

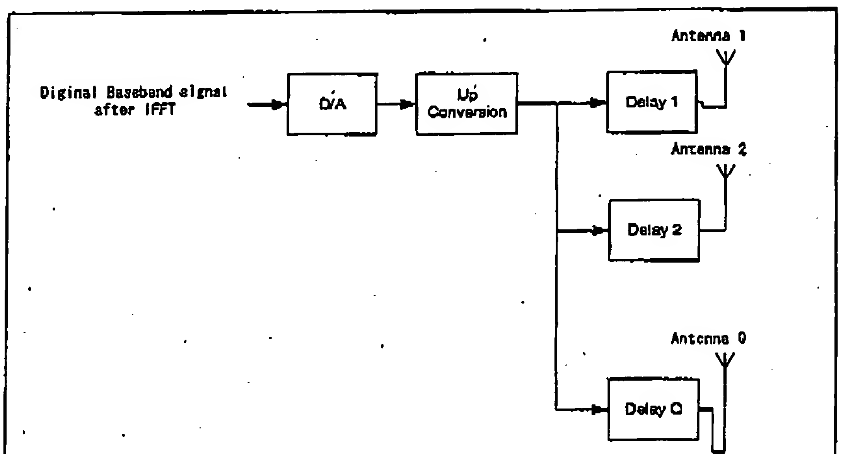

Fig. 7

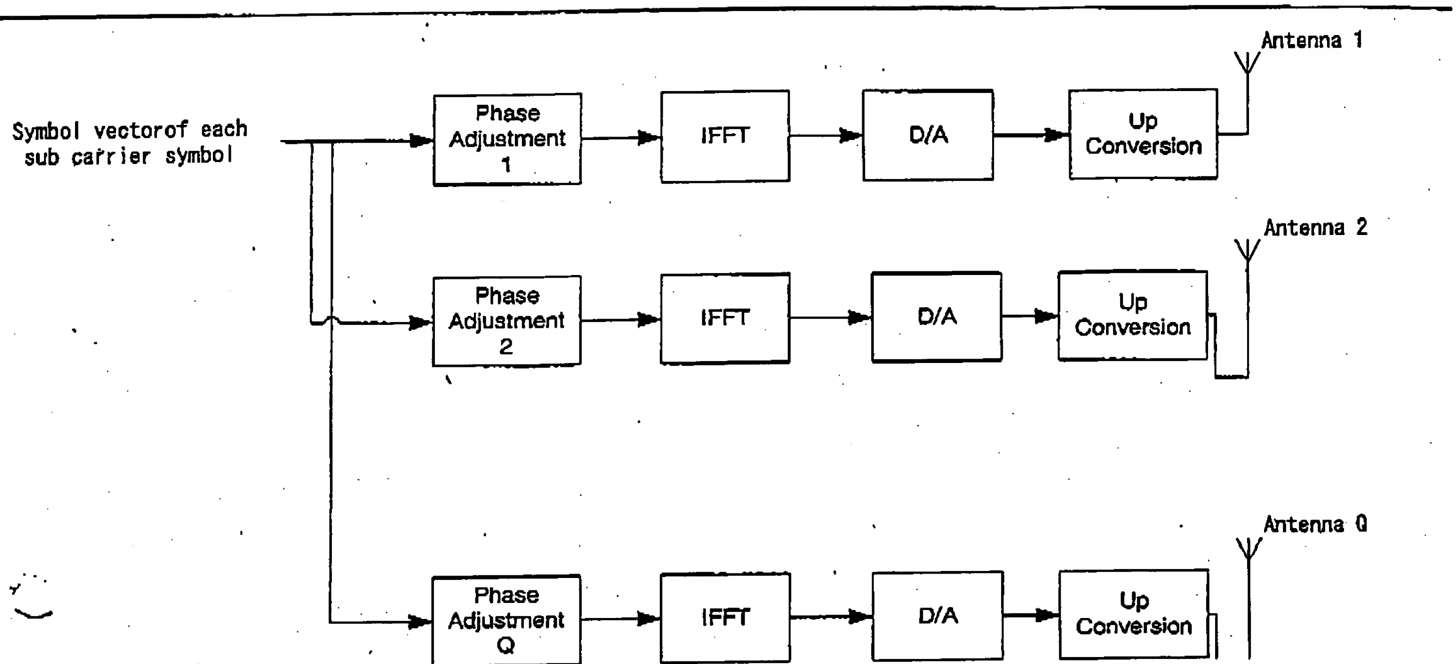
Symbol vectorof each sub carrier symbol
Phase Adjustment 1
IFFT
D/A
Up Conversion
Antenna 1
Phase Adjustment 2
IFFT
D/A
Up Conversion
Antenna 2
Phase Adjustment Q
IFFT
D/A
Up Conversion
Antenna Q

Fig. 8

8 Closed loop mode transmit diversity

The general transmitter structure to support closed loop mode transmit diversity for DPCH transmission is shown in Figure 6. Channel coding, interleaving and spreading are done as in non-diversity mode. The spread complex valued signal is fed to both TX antenna branches, and weighted with antenna specific weight factors w_1 and w_2. The weight factors are complex valued signals (i.e., $w_i = a_i + jb_i$), in general.

The weight factors (actually the corresponding phase adjustments in closed loop mode 1 and phase/amplitude adjustments in closed loop mode 2) are determined by the UE, and signalled to the UTRAN access point (=cell transceiver) using the D-bits of the FBI field of uplink DPCCH.

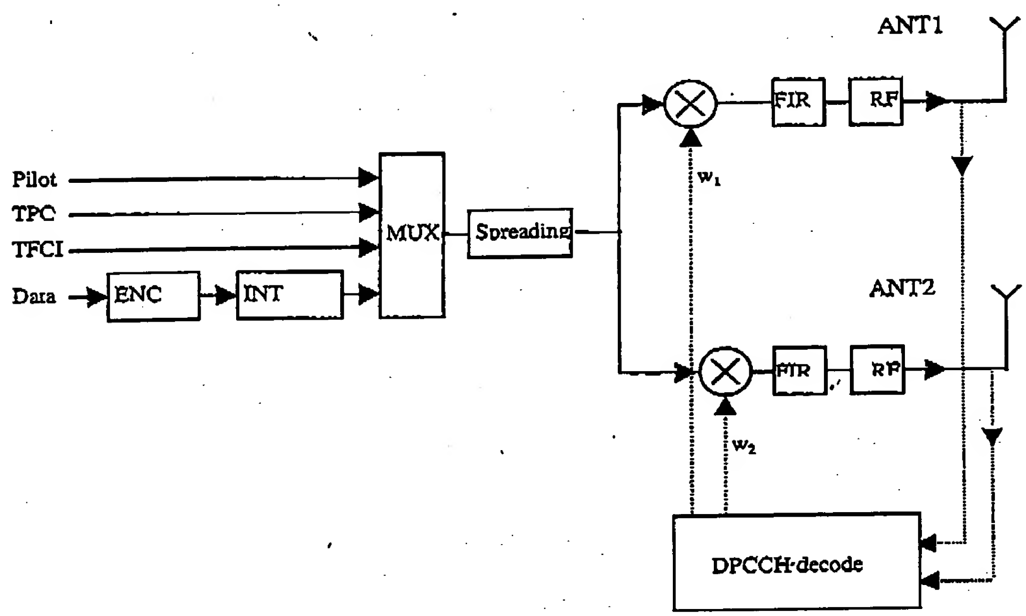

Figure 6 : The generic downlink transmitter structure to support closed loop mode transmit diversity for DPCH transmission (UTRAN Access Point)

There are two closed loop modes whose characteristics are summarized in the Table 8. The use of the modes is controlled by the UTRAN access point.

Table 8 : Summary of number of feedback information bits per slot, N_{FBD}, feedback command length in slots, N_W, feedback command rate, feedback bit rate, number of phase bits, N_{ph}, per signalling word, number of amplitude bits, N_{po}, per signalling word and amount of constellation rotation at UE for the two closed loop modes.

Closed loop mode	N_{FBD}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}	Constellation rotation
1	1	1	1500 Hz	1500 bps	0	1	$\pi/2$
2	1	4	1500 Hz	1500 bps	1	3	N/A

8.1 Determination of feedback information

The UE uses the Common PIlot CHannel (CPICH) to separately estimate the channels seen from each antenna.

Once every slot, the UE computes the phase adjustment, ϕ, and for mode 2 the amplitude adjustment that should be applied at the UTRAN access point to maximise the UE received power. In non-soft handover case, that can be accomplished by e.g. solving for weight vector, $\underline{w}$, that maximises

$$P=\underline{w}^H H^H H \underline{w} \qquad (1)$$

where

$$H=[\underline{h}_1 \ \underline{h}_2 \ ]$$

and where the column vectors $\underline{h}_i$ and $\underline{h}_2$ represent the estimated channel impulse responses for the transmission antennas 1 and 2, of length equal to the length of the channel impulse response. The elements of w correspond to the phase and amplitude adjustments computed by the UE.

During soft handover or SSDT power control, the antenna weight vector, $\underline{w}$ can be, for example, determined so as to maximise the criteria function,

$$P=\underline{w}^H(H_1{}^H H_1 + H_2{}^H H_2 + \cdots)\underline{w} \qquad (2)$$

where H_i is an estimated channel impulse response for BS#i. In regular SHO, the set of BS#i corresponds to the active set. With SSDT, the set of BS#i corresponds to the primary base station(s).

The UE feeds back to the UTRAN access point the information on which phase/power settings to use. Feedback Signalling Message (FSM) bits are transmitted in the portion of FBI field of uplink DPCCH slot(s) assigned to FB Mode Transmit Diversity, the FBI D field (see 25.211). Each message is of length $N_W = N_{po}+N_{ph}$ bits and its format is shown in the Figure 7. The transmission order of bits is from MSB to LSB, i.e. MSB is transmitted first. FSM_{po} and FSM_{ph} subfields are used to transmit the power and phase settings, respectively.

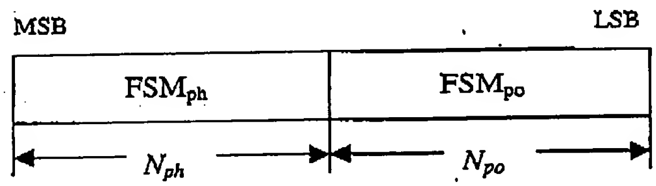

Figure 7 : Format of feedback signalling message. FSM_{po} transmits the power setting and FSM_{ph} the phase setting.

The adjustments are made by the UTRAN Access Point at the beginning of the downlink DPCCH pilot field.

8.2 Closed loop mode 1

UE uses the CPICH transmitted both from antenna 1 and antenna 2 to calculate the phase adjustment to be applied at UTRAN access point to maximize the UE received power. The received CPICH can be denoted as:

$$S^1_{CPICH}(t) = a_1(t)e^{j\phi_1(t)} \qquad (2)$$

$$S^2_{CPICH}(t) = a_2(t)e^{j\phi_2(t)} \qquad (3)$$

where,

$S^1_{CPICH}(t)$ = common pilot signal from antenna 1

$a_1(t)$ = time varying amplitude of the $S^1_{CPICH}(t)$

ϕ_1(t) = time varying phase of the $S^1_{CPICH}(t)$

$S^2_{CPICH}(t)$ = common pilot signal from antenna 2 (diversity antenna)

$a_2(t)$ = time varying amplitude of the $S^2_{CPICH}(t)$

$\phi_2(t)$ = time varying phase of the $S^2_{CPICH}(t)$

Before solving for the optimum phase adjustment, the S^2_{CPICH} is rotated as follows:

$$S^2_{CPICH}(t) = a_2(t)e^{j\phi_2(t)}e^{j\phi_r(t)} \tag{4}$$

The rotation angle, $\phi_r(t)$, which is applied before solving for phase adjustment to be signaled in uplink slot i, is defined as:

$$\phi_r(t) = \begin{cases} 0, & i = 0,2,4,6,8,10,12,14 \\ \frac{\pi}{2}, & i = 1,3,5,7,9,11,13 \end{cases} \tag{5}$$

After rotation of the S^2_{CPICH} by $\phi_r(t)$, UE calculates the optimum phase adjustment, ϕ, which is then quantized into ϕ_Q having two possible values as follows:

$$\begin{array}{llll} \frac{-\pi}{2} < \phi & \frac{\pi}{2} & \mathrm{T} & \phi_Q = 0 \\ \frac{\pi}{2} < \phi & \frac{3\pi}{2} & \mathrm{T} & \phi_Q = \pi \end{array} \tag{6}$$

If $\phi_Q = 0$, a command '0' is send to UTRAN using the FSM_{ph} field. Correspondingly, if $\phi_Q = \pi$, command '1' is send to UTRAN using the FSM_{ph} field.

Due to rotation of the constellation at UE the UTRAN interprets the received commands according to Table 9 which shows the mapping between phase adjustment, ϕ_i, and received feedback command for each UL slot.

Table 9 : Feedback commands and corresponding phase adjustments, ϕ_i, for the slots i of the UL radio frame.

FSM$_{ph}$	ϕ_i														
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	0	π/2	0	π/2	0	π/2	0	π/2	0	π/2	0	π/2	0	π/2	0
1	π	-π/2	π	-π/2	π	-π/2	π	-π/2	π	-π/2	π	-π/2	π	-π/2	π

The weight vector, w_2, is then calculated by sliding window averaging the received phases over 2 consequtive slots. Algorithmically, w_2 is calculated as follows:

$$w_2 = \frac{\underset{i=n-1}{\overset{n}{\alpha}} \cos(\phi_i)}{\sqrt{2}} + j\frac{\underset{i=n-1}{\overset{n}{\alpha}} \sin(\phi_i)}{\sqrt{2}} \tag{7}$$

where,

$$\phi_i \;\mathrm{I}\; \{0, \pi, \pi/2, -\pi/2\} \tag{8}$$

For antenna 1, the weight vector, w_1, is always:

$$w_1 = 1 \tag{9}$$

8.2.1 Mode 1 end of frame adjustment

In closed loop mode 1 at frame borders the sliding window averaging operation is slightly modified. Upon reception of the FB command for slot 0 of the next frame, the average is calculated based on the command for slot 13 of the previous frame and the command for slot 0 of the next frame, i.e. ϕ_i from slot 14 is not used:

$$w_2 = \frac{\cos(\phi_{13}^{j-1}) + \cos(\phi_0^j)}{\sqrt{2}} + j\frac{\sin(\phi_{13}^{j-1}) + \sin(\phi_0^j)}{\sqrt{2}} \tag{10}$$

where,

ϕ_{13}^{j-1} = phase adjustment from frame j-1, slot 13

ϕ_0^j = phase adjustment from frame j, slot 0

8.2.2 Mode 1 normal initialization

For the first frame of transmission UE determines the feedback commands in a normal way and sends them to UTRAN.

Having received the first FB command the UTRAN calculates the w_2 as follows:

$$w_2 = \frac{\cos(\pi/2) + \cos(\phi_0)}{\sqrt{2}} + j\frac{\sin(\pi/2) + \sin(\phi_0)}{\sqrt{2}} \tag{11}$$

where,

ϕ_0 = phase adjustment from slot 0 of the first frame

8.2.3 Mode 1 operation during compressed mode

8.2.3.1 Downlink in compressed mode and uplink in normal mode

When downlink is in compressed mode but uplink is operating normally (i.e. not compressed) the UTRAN continues it's Tx diversity related functions in the same way as in non-compressed downlink mode.

If UE continues to calculate the phase adjustments based on the received CPICH from antennas 1 and 2 during the idle downlink slots there is no difference in UE operation when compared to non-compressed downlink operation.

If during the compressed downlink transmission there are uplink slots for which no new estimate of the phase adjustment has been calculated the following rules are applied in UE when determining the feedback command:

1. If no new estimate of phase adjustment, ϕ_i, exist corresponding to the feedback command to be send in uplink slot i:

    If $1 < i < 15$
        the feedback command sent in uplink slot i-2 is used
    else if $i = 0$
        the feedback command sent in uplink slot 14 of previous frame is used
    else if $i = 1$
        the feedback command sent in uplink slot 13 of previous frame is used
    end if

2. When transmission in downlink is started again in downlink slot N_{Last+1} the UE must resume calculating new estimates of the phase adjustment. The feedback command corresponding to the first new estimate of ϕ_i must be send in the uplink slot which is transmitted 1024 chips in offset from the downlink slot N_{Last+1}.

8.2.3.2 Both downlink and uplink in compressed mode

During the uplink idle slots no FB commands are sent from UE to UTRAN. When transmission in downlink is started again in downlink slot N_{Last+1} the UE must resume calculating new estimates of the phase adjustment. The feedback command corresponding to the first new estimate of ϕ_i must be send in the uplink slot which is transmitted 1024 chips in offset from the downlink slot N_{Last+1}.

The UTRAN continues to update the weight vector, w_2, until the uplink enters the compressed mode and no more FB commands are received. When the transmission in downlink resumes in slot N_{Last+1}, the value of w_2 calculated after receiving the last FB command before uplink entered the compressed mode is applied to antenna 2 signal.

After UE resumes transmission in uplink and sends the first FB command the new value of w_2 is calculated as follows:

$S_1 = \{0, 2, 4, 6, 8, 10, 12\ 14\}$
$S_2 = \{1, 3, 5, 7, 9, 11, 13\}$

i = number of uplink slot at which the transmission resumes
j = number of uplink slot at which the last FB command was send before uplink entered compressed mode

```
do while (i I S1 and j I S1) or (i I S2 and j I S2)
    j = j-1
    if j < 0
        j = 14
    end if
end do
```

calculate w_2 based on FB commands received in uplink slots i and j

8.3 Closed loop mode 2

In closed loop mode 2 there are 16 possible combinations of phase and amplitude adjustment from which the UE selects and transmits the FSM according to Table 10 and Table 11. As opposed to closed loop Mode 1, no constellation rotation is done at UE and no filtering of the received weights is performed at the UTRAN.

Table 10 : FSM_{po} subfield of closed loop mode 2 signalling message.

FSM_{po}	Power_ant1	Power_ant2
0	0.2	0.8
1	0.8	0.2

Table 11 : FSM_{ph} subfield of closed loop mode 2 signalling message.

FSM_{ph}	Phase difference between antennas (degrees)
000	180
001	-135
011	-90
010	-45

110	0
111	45
101	90
100	135

When N_{po}=0, equal power is applied to each antenna.

To obtain the best performance, progressive updating is performed at both the UE and the UTRAN Access point. Every slot time, the UE refines its choice of FSM, from the set of weights allowed given the previously transmitted bits of the FSM. This is shown in Figure 8, where, in this figure b_i ($0<i<3$) are the bits of the FSM (from Table 10 and Table 11) from the MSB to the LSB and m=0, 1, 2, 3 (the end of frame adjustment given section 8.3.1 is not shown here).

At the beginning of a FSM to be transmitted, the UE chooses the best FSM out of the 16 possibilities. Then the UE starts sending the FSM bits from the MSB to the LSB in the portion of FBI field of the uplink DPCCH during 4 (FSM message length) slots. Within the transmission of the FSM the UE refines its choice of FSM. This is defined in the following. :

Define the 4 bits of FSM, which are transmitted from slot number k to k+3, as $\{b_3(k)\ b_2(k+1)\ b_1(k+2)\ b_0(k+3)\}$, where k=0, 4, 8, 12. Define also the estimated received power criteria defined in Equation 1 for a given FSM as $p(\{x_3\ x_2\ x_1\ x_0\})$, where $\{x_3\ x_2\ x_1\ x_0\}$ is one of the 16 possible FSMs which defines an applied phase and amplitude offset according to Table 10 and Table 11. The $b_i()$ and x_i are 0 or 1.

The bits transmitted during the m fth FS Mof the fra me where m=0 1 2 3 are then given b

$b_3(4m)=X_3$ from the $\{X_3\ X_2\ X_1\ X_0\}$ which maximises $p(\{x_3\ x_2\ x_1\ x_0\})$ over all x_3,x_2,x_1,x_0 (16 possible combinations);

$b_2(4m+1)=X_2$ from the $\{b_3(4m)\ X_2\ X_1\ X_0\}$ which maximises $p(\{b_3(4m)\ x_2\ x_1\ x_0\})$ over all x_2,x_1,x_0 (8 possible combinations);

$b_1(4m+2)=X_1$ from the $\{b_3(4m)\ b_2(4m+1)\ X_1\ X_0\}$ which maximises $p(\{b_3(4m)\ b_2(4m+1)\ x_1\ x_0\})$ over all x1,x0 (4 possible combinations);

$b_0(4m+3)=X_0$ from the $\{b_3(4m)\ b_2(4m+1)\ b_1(4m+2)\ X_0\}$ which maximises $p(\{b_3(4m)\ b_2(4m+1)\ b_1(4m+2)\ x_0\})$ over x_0 (2 possible combinations).

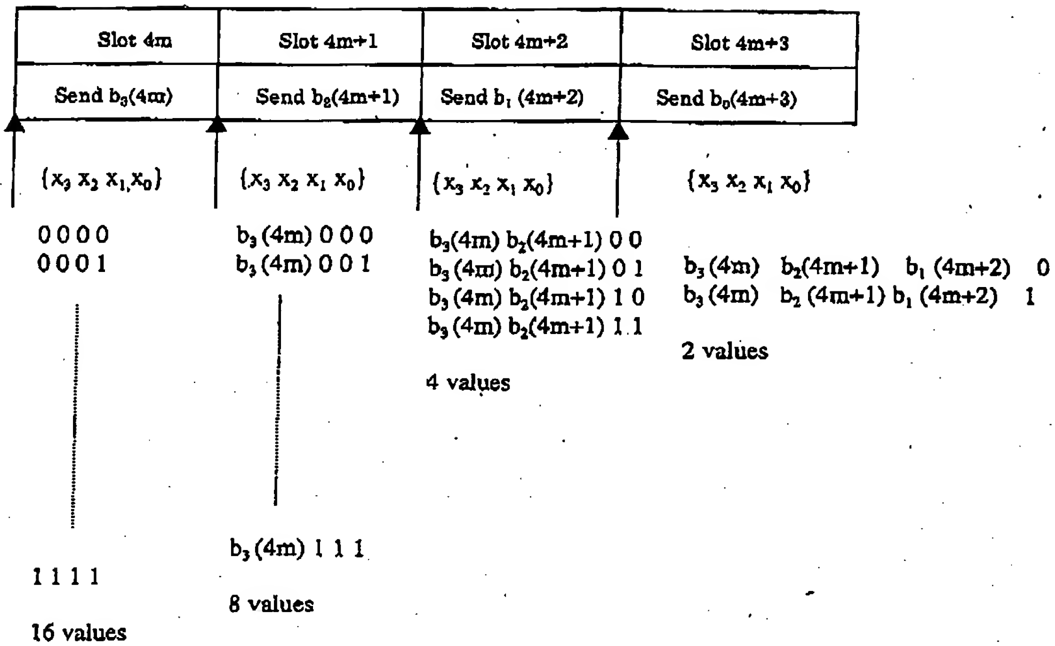

Figure 8 : Progressive Refinement at the UE for closed loop mode 2.

Every slot time the UTRAN constructs the FSM from the most recently received bits for each position in the word and applies the phase and amplitude as defined by Table 10 andTable 11. More precisely, the UTRAN operation can be explained as follows. The UTRAN maintains a register $z=\{z_3\ z_2\ z_1\ z_0\}$, which is updated every slot time according to $z_i=b_i(ns)$ $(i=0:3, ns=0:14)$. Every slot time the contents of register z are used to determine the phase and amplitude adjustments as defined by Table 10 andTable 11, with $FSM_{ph}=\{z_3\ z_2\ z_1\}$ and $FSM_{po}=z_0$.

Special procedures for initialisation and end of frame processing are described below.

The weight vector, w, is then calculated as:

$$\underline{w}=\begin{bmatrix}\sqrt{power\_ant1} \\ \sqrt{power\_ant2}.\exp(j\pi.phase\_diff/180)\end{bmatrix} \quad (6)$$

8.3.1 Mode 2 end of frame adjustment

The FSM must be wholly contained within a frame. To achieve this an adjustment is made to the last FSM in the frame where the UE only sends the FSM_{ph} subfield, and the Node B takes the amplitude bit FSM_{po} of the previous FSM.

8.3.2 Mode 2 normal Initialisation

For the first frame of transmission using closed loop mode 2, the operation is as follows.

The UE starts sending the FSM message in slot 0 in the normal way, refining its choice of FSM in slots 1 to 3 from the set of weights allowed given the previously transmitted bits of the FSM.

During the reception of the first three FSM bits (that is before the full four bits are received), the UTRAN Access Point initialises its transmissions as follows. The power in both antennas is set to 0.5. The phase offset applied between the antennas is updated according to the number and value of FSM_{ph} bits received as given in Table 12.

Table 12 : FSM_{ph} normal initialisation for closed mode 2.